

# **III. THE LAKES OF NORTHEASTERN INDIANA**

**By**

**Will Scott**

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## INTRODUCTION

This study is concerned with the principal lakes of four counties of north-eastern Indiana, i. e., Steuben, LaGrange, Noble, and Whitley. Not all the lakes of these counties have been examined, but the number studied includes all types and gives a fair and sound picture of conditions in this region. The summer of 1929 was devoted to the lakes of Steuben County. A temporary camp and laboratory was set up at the state park on Lake James. The central location of this point and the special interest attaching to Lake James made this location very advantageous. In 1930 the lakes of the other three counties were reached from the Biological Station of Indiana University. A smaller number of lakes were examined in 1930 because the lakes were farther apart and the consequent travel greater.

It is frankly an exploratory study. Dr. W. M. Tucker, working for the Department of Conservation, had mapped Lakes James, Snow, Crooked, Clear, and Gage in Steuben County; Adams and Oliver Lakes in Noble County; and Crooked, Shriner, and Round Lakes in Whitley County. Other than this nothing was known of this group except the incidental work done on them by Dayer in his work on the topography and glaciation of the region, and the mere superficial descriptions of some of them by various people.

It is well known that the summer temperature and the consequent distribution of dissolved oxygen, and carbon dioxide together with the amount of carbonates in a lake are fundamental elements in their economy. This together with the summer plankton gives a fair picture of the nature of any lake.

These facts have been determined and expressed in a series of 68 tables. These data are discussed in the body of the paper and some deductions are made. Certain difficulties have been met. The most important is the lack of topographic maps of the region. Problems connected with the carbonates are intimately related to the topography and their solution awaits the construction of such maps. A minor difficulty has been the naming of the lakes discussed in the paper. The same lake often has more than one name; for instance, Hamilton and Fish refer to the same lake, as do Garden and Golden. The same name is often applied to different lakes. The name Crooked is applied to rather important lakes in both Steuben and Whitley Counties. To obviate this difficulty a table is introduced giving the township, range, and sections occupied in part or in whole by each lake.

## ACKNOWLEDGMENTS

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The field assistants in 1929 were Herman T. Spieth, Raymond J. Myers, and Ancil D. Holloway. In 1930 they were Raymond J. Myers and Mychyle W. Johnson. Their careful work adds much to the quality of the results.

In the laborious work of counting the plankton, I was assisted by Miss Mary I. Spilman and Miss Lois E. Smith. I am also indebted to Dr. Harold T. Davis and Miss Anna Mae Lescisin of the Department of Mathematics for calculating the coefficient of correlation between the carbonates and certain diatoms.

The Graduate School of Indiana University furnished funds for the apparatus and incidental expenses. I am especially grateful to Dr. Fernandus Payne, its Dean and my colleague, for his kindly encouragement.

TABLE No. 1. Location of lakes by township, range, and section. The serial numbers at the left correspond to the numbers on fig. 1, which is the map of the four counties.

LAKE	TN	RE	Sec.
1. Adams, Lagrange.....	36	10	23-24-25-26
2. Cedar, Lagrange.....	38	10	21-22
3. Cedar, Whitley.....	32	9	2-11-12
4. Center, Steuben.....	37	13	22
5. Clear, Steuben.....	38	15	17-18-19-20-29-30
6. Crooked, Steuben.....	37 37	13 12	6-7-8-9-16-17 1
7. Crooked, Whitley.....	32 33	9 9	3-4 33-34
8. Fox, Steuben.....	37	13	28-33-34
9. Gage, Steuben.....	38 37	12 12	34-35 2
10. George, Steuben.....	38	13	14-15+Mich.
11. Golden, Steuben.....	36 36	12 12	1 5-6-8
12. Hamilton, Steuben.....	36	14	28-33-21-27
13. Hog, Steuben.....	38	13	17+Mich.
14. Hogback, Steuben.....	37 37	12 13	25-36 31
15. James, Steuben.....	38 37	13 13	28-33-34 3-4-10
16. Jimerson, Steuben.....	38 37	13 13	30-31-32 5
17. Lake Pleasant, Steuben.....	38 38	13 12	18- 12-13+Mich.
18. Long, Lagrange.....	36	11	22-26-27
19. Long, Steuben.....	36	13	15-16
20. Loon, Steuben.....	37	13	20
21. Marsh, Steuben.....	38	13	25
22. Oliver, Lagrange.....	36	10	17-18-19-20
23. Otter (L.), Steuben.....	38	13	26-27
24. Otter (U.), Steuben.....	38	13	26-27
25. Pleasant L., Steuben.....	36	13	22-23-14-15
26. Pretty, Lagrange.....	36	11	15-16
27. Round, Whitley.....	32	9	12
28. Shriner, Whitley.....	32	9	2-11-12
29. Silver, Steuben.....	37	13	29-30-31-32
30. Snow, Steuben.....	38	13	21-22-27-28
31. Big Turkey {Lagrange..... {Steuben.....	36 36	12 11	7-18 13
32. Twin (N.), Lagrange.....	38	9	23
33. Twin (S.), Lagrange.....	38	9	26-27
34. Wallen, Noble.....	35	13	13

TN—Township North.

RE—Range East.

SEC.—Section.

Serial numbers indicate lake names on map No. 1.

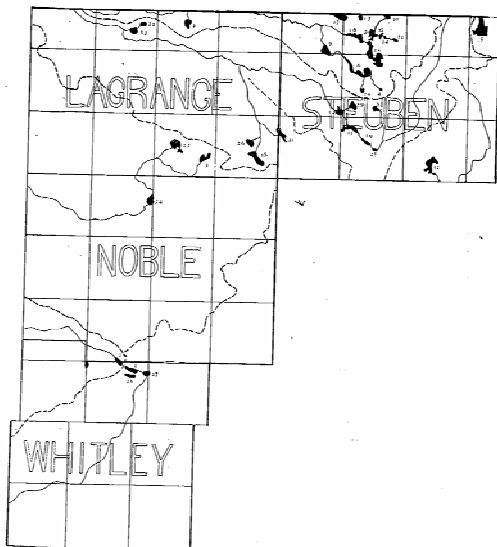


FIG. 1. Map of the area. Figures refer to lake names in Table No. 1.

## DRAINAGE

The four counties Steuben, LaGrange, Noble, and Whitley, which include the lakes of this report, form a "parting of the ways" so far as surface drainage is concerned. From them the waters may go to Lake Erie through the Maumee, to Lake Michigan through the St. Joseph of Michigan, or to the Gulf of Mexico through the tributaries of the Wabash which in turn empties into the Ohio and thence to the Mississippi and the Gulf.

In Whitley County, Cedar, Shriner and Round Lakes are drained by the Eel River, which is tributary to the Wabash. Over a low divide is Crooked Lake of Whitley County, which empties into the Wabash through the Tippecanoe River.

Adams and Oliver Lakes of LaGrange County and Wallen Lake of Noble County are tributary to the Elkhart River. Fox, Pleasant, Long, Golden, and Silver Lakes of Steuben County; Big Turkey Lake of Steuben and LaGrange Counties; and Long, Pretty, North Twin, and South Twin Lakes of LaGrange County all empty into the Pigeon River.

Faun River drains two series in Steuben County. The first series is composed of Marsh, Upper Otter, Lower Otter, George, Snow, James, and Jimerson Lakes. The second consists of Center, Loon, Crooked, and Gage. In addition to this, the Faun River drains Cedar Lake of LaGrange County. These three rivers, the Elkhart, the Pigeon, and the Faun, are tributaries of the St. Joseph River of Michigan. The St. Joseph also drains Lake Pleasant and Hog Lake. The outlet of Clear Lake flows northwest and south through Michigan and Ohio to St. Joseph of the Maumee. Hamilton reaches the same stream through Fish Creek.

## GLACIATION AND LAKE FORMATION

The lakes of this region are due to the Pleistocene glaciation. While much glacial drift was undoubtedly brought into Indiana by the earlier ice advances, the present distribution and topography are due to the last or Wisconsin ice sheet. This ice sheet advanced into Indiana in three great lobes, which were given direction by the basins of Lake Michigan, Saginaw Bay of Lake Huron, and the combined influences of Lakes Huron and Erie. Consequently, these lobes are called the Michigan, the Saginaw, and the Huron-Erie. Of these three lobes the Huron-Erie advanced into the northern part of eastern Indiana from the northeast; the Michigan lobe advanced into western Indiana from the north, and between these two came the Saginaw Lobe. The influence of the Michigan Lobe is outside the area considered in this paper and will not be discussed.

Leverett (1915) has determined that the Saginaw Lobe retreated first. The general climatic conditions at the same latitude must have been uniform over all three lobes. The early retreat of the Saginaw indicates that it had less mass and power than the other two. This fact and the form of the moraines (Leverett, L. C., map No. VI.) indicate that ice derived from the Saginaw lobe did not extend south of the present Wabash River nor its major tributary, the Eel River.



This massive system of moraines extends from the northeast corner of the state southwest for about seventy-five miles. In this mass occur the lakes which are discussed in this paper. While Dryer (1891, pp. 114-120) and Leverett (l. c.) attribute most of this material to the work of the Huron-Erie lobe, the region must be regarded as interlobate in the sense that both lobes influence it.

From this mass which coalesces in Steuben and a part of Noble and DeKalb Counties, there extends southwest three limbs. The eastern one is the ill defined Salamonie moraine, the middle one becomes the Mississinewa. Both of these are clearly terminal moraines of the Huron-Erie lobe.

The third and western of these three extends to the southwest, paralleling the Eel River from Whitley County to Logansport. It was along this western mass and in the coalesced moraines from Whitley County to the northeast that the great ice lobes were in contact at the time of the maximum development of the Saginaw lobe. Not only did each contribute material from its lateral and terminal moraine, but as the opposing masses varied both in thickness and force, there must have been local over-riding of one mass by the other. For reasons already given, the Huron-Erie usually did the over-riding. This resulted in buried masses of ice which eventually, on melting, caused lake beds and outwash channels.

In the case of Tippecanoe Lake and the Barbee system, it was determined (Scott, 1915, p. 5) that the drainage lines were between finger-like lobes of ice. Great water-laid deposits were laid down between masses of ice. When the ice melted, the anomalous condition was produced, namely, lakes separated by water-laid ridges.

Dryer (1891, p. 133) accurately describes the condition in Steuben County as two great moraines running northeast to southwest and the streams running to the northwest. Three of these streams follow channels through the western and more massive of these two moraines. His interpretation that these channels antedate the moraines is incorrect. Also his interpretation that they formed outwash channels from the Huron-Erie Lobe is untenable, unless it is assumed that there were great masses of stagnant ice underlying these water courses and that the subsequent melting of these ice masses caused the lakes now found in these valleys.

The accurate interpretation of this whole interlobate region must await detailed studies. These studies must include the making of a topographic map, the correlation of the logs of wells, study of the water stratified drift, outwash channels, and the identification of the materials of the deposits and their point of origin. Until these data are at hand speculation as to details is futile.

## CARBONATES

These lakes are all relatively hard water lakes. The "hardness" is due to carbonates, chiefly those of calcium, although a smaller amount of magnesium is usually present. These carbonates vary from 24.96 cc. of carbon dioxide per liter in Loon Lake to 54.73 in Golden Lake.

The carbonates are leached from the glacial deposits above the lake levels, and their primary source is the limestones and dolomites of the Devonian and

Silurian deposits to the northeast. They are found on the shores of Lakes Huron and Erie, on the east side of the "thumb" of Michigan, in Ohio, and in southern Ontario. These glacial deposits are very heterogenous. Many analyses will have to be made before any significant average is obtained. Collections fifteen to twenty feet below the surface in a fresh gravel pit near Winona Lake averaged 9.4% of calcium carbonate. Besides this little known factor, the amount of carbonate in the moraines, two processes seem to influence the amount of carbonates in a lake, namely, the leaching of the carbonates from the moraine above the lake level and the precipitation by photosynthesis of the carbonates from the lake water as marl. The first of the processes increases the carbonates while the second reduces it in amount. When a lake is perched high in the moraines, the water is softer than when the level of the lake is much lower than the surrounding moraines. For instance, near the divide between the Faun and Pigeon Rivers lie Center and Loon Lakes on one side, and Fox and Silver Lakes on the other. Their carbonates average respectively 31.92, 24.96, 29.72 and 31.26.

At lower elevations in this same moraine and river valleys lie Long, Garden, and Hogback Lakes on one side and Marsh, Otter and James on the other—whose carbonates average 52.39, 54.73, 44.49, 47.25, 45.96 and 38.00, respectively.

This is illustrated also in the series of lakes whose drainage unites to form the Faun River. The largest lake in one series is James Lake, and in the other is Crooked Lake. Approximately a mile apart they lie, but with a difference in elevation of 23.5 feet (Tucker, 1922, p. 400). The average carbonates for Crooked Lake is 26.37 while that for James is 38.00.

The James series, with their carbonates, consist of Marsh 48.95, Upper Otter 47.45, Lower Otter 41.02, Snow 41.00, James 38.00, Jimerson 36.67.

The Crooked Lake series follows: Center 31.92, Loon 24.96, Crooked 26.37, Gage 30.22. The arithmetical average for the perched lakes, i. e., the Crooked Lake series, is 28.36, while that for the lower lake series is 42.18.

The "softening" of lakes by photosynthesis is the result of the following well known facts. The carbonates in solution in lake water are in the form of the bicarbonate. In photosynthesis the plants not only use the free carbon dioxide in solution, but are also able to use the second radical of the bicarbonate, the so-called "half bound" carbon dioxide. This leaves the normal carbonate which is precipitated as "marl."

In a series of lakes whose difference in level is slight and which are connected by streams of considerable volume, the amount of carbonate in solution is gradually reduced. This is best illustrated in the series Marsh, Upper Otter, Lower Otter, Snow, James, and Jimerson Lakes cited above.

In other instances variations in leaching caused by variation in the differential between the lake level and the level of the surrounding moraines overbalance the effect of photosynthesis. In the series of lakes which is tributary to the Pigeon River, Pleasant Lake is little below the level of the surrounding land while farther down lies Golden and Hogback surrounded by high moraines. The former has 27.15 cc. carbonates while the latter have 54.73 and 44.49, respectively. Golden is the highest in carbonates of any lake examined in this study.

LAKE	SURFACE AND BOTTOM							
	Depth	T		O <sub>2</sub>		CO <sub>2</sub> Free		Cb
1. Center.....	5. 5.	23.7 25.	18.9 24.4	3.57 5.38	0 0	0 .74	6.97 5.68	30.37 33.86 30.15 32.12
2. Clear.....	32.50 30.	22.2 24.2	10.4 10.2	5.71 6.41	.08 1.58	-.99 -1.23	5.72 4.94	24.40 28.18 24.96 27.18
3. Crooked.....	21. 23.	26.7 22.2	10.6 10.4	5.91 5.5	0 .8	0 0	7.85 1.5	22.93 28.79 24.63 28.11
4. Fox.....	17.5	24.4	10.8	6.2	0	-1.22	5.13	26.42 33.02
5. Golden.....	9.5	26.1	11.7	5.15	0	3.19	18.45	46.00 63.46
6. Gage.....	21. 21.5	24.4 22.2	10.6 10.6	5.31 5.9	0 0	0 -.99	8.46 5.47	26.64 39.59 28.86 31.39
7. George.....	25. 25.	25.6 23.3	11.1 11.1	6.23 5.7	.1 .9	0 0	6.47 5.47	27.63 34.86 30.60 33.09
8. Hamilton(Fish)	19. 19.	27.2 24.4	11.7 11.7	6.56 7.2	0 .05	-.73 -1.23	7.32 9.63	24.40 29.03 26.44 30.39
9. Hog.....	9.	26.6	13.3	6.09	.34	0	-7.03	27.92 36.54
10. Hogback.....	5.5 8.	24.4 24.4	15.6 13.9	6.03 5.05	0 0	0 0	17.25 16.79	40.86 58.21 40.17 48.12
11. Jimerson.....	17.	24.4	10.	5.57	.06	0	5.68	33.61 39.54
12. Lake Pleasant.	10.	25.6	14.4	5.57	.21	0	4.54	24.97 28.60
13. Long.....	9.5	24.4	12.2	5.33	0	.6	5.74	47.72 57.07
14. Loon.....	4.	26.7	21.4	4.76	1.99	.98	3.93	24.10 25.83
15. Marsh.....	11.	25.6	10.	6.73	.10	0	9.27	50.75 44.16
16. (Lower) Otter.	12.	24.8	10.	5.89	.11	0	6.92	42.01 40.03
17. (Upper) Otter.	10.	25.6	10.6	6.20	.07	0	6.40	50.66 41.27
18. Pleasant Lake.	13.	25.9	11.7	5.7	.67	0	5.13	24.40 29.84
19. Silver.....	11.	25.	11.7	5.00	.10	0	8.17	26.33 36.09
Depth 30+ Clear								
20-29 Crooked, Gage, George.								
10-19 Fox, Hamilton, Jimerson, L. Pleasant, L. Otter, U. Otter, Pleasant Lake, Silver.								
10 Center, Golden, Hog, Hogback, Loon.								

TABLE No. 2. Summary table for the lakes of Steuben County.

Birge and Juday (1911, p. 136) have shown that extremely soft water lakes such as those of northeastern Wisconsin are relatively poor in plankton especially phytoplankton. The above mentioned authors divide the lakes of Wisconsin into three classes with reference to carbonates, namely, soft, medium, and hard. The soft water lakes contain carbondioxide as carbonate in amounts less than 5 cc. per liter, the medium 5 cc. to 22 cc. per liter, and the hard water lakes above 22 cc. per liter. On this basis, all lakes considered in this paper are hard water lakes varying in carbonates from 24.96 cc. per liter to 54.73.

Theoretically the amount of phytoplankton should be roughly proportional to the amount of carbonates. Plant growth is also dependent upon other factors. The form of the basin is a potent factor. The shallower lakes generally produce more phytoplankton than the deeper lakes. For example, Hogback Lake with a depth of 8.5 meters has more phytoplankton than any other lake of the series, while Clear Lake of Steuben County, with a depth of 32 meters, is relatively low in phytoplankton.

Rice (1916) and others have shown that the amount and nature of nitrogen compounds are related to plant growth in water. Atkins (1924) has shown a similar relation for phosphorous. Allen (1914) finds some unknown organic compound necessary for the artificial culture of marine plankton.

In spite of these and other factors known to influence plant growth, it appeared probable from the inspection of our data that the number of certain diatoms was correlated with the amount of carbonates.

The average amount of carbonates in thirty-two lakes was determined by taking the arithmetical average of the maximum and minimum. (The volume of most of the lakes is unknown, so that the amount of the carbonates could not be more closely determined.) The coefficient of correlation between this average of the carbonates and the number of three phytoplanktons *Fragillaria*, *Melosira*, and *Clathrocystis* was .4549, .4559, and .0284, respectively.

It appears from this that in spite of other factors influencing plant growth, there is a significant correlation between the carbonates and diatoms, but not between carbonates and blue green algae. Correlations above .3 are usually regarded as significant. These diatom correlation factors are nearer .5 than .4.

## OXYGEN

In discussing the distribution of oxygen, it is necessary to recall the thermal stratification during the summer of lakes in temperate latitudes. Due chiefly to thermal resistance to mixture, lakes become stratified during the warmer months into a warm upper layer, beneath which is a stratum whose temperature decreases rapidly as the depth increases, and below this is a region of relatively cold water. These are known respectively as the epilimnion thermocline (mesolimnion) and the hypolimnion. In these lakes the epilimnion is usually five or six meters thick. The thermocline extends from a depth of five or six meters to a depth of ten to twelve meters. The hypolimnion occupies the depth beyond ten or twelve meters. This stratification is usually established by the first of June and lasts until the middle of October in the shallower lakes, and about a month longer in the deeper lakes.

In addition to the thermal stratification of lakes, the amount of oxygen is influenced in the upper levels by photosynthesis which in turn is determined by the amount of incident solar energy and the depth to which the various wave lengths penetrate. The amount of incident energy at the equinox when the sun is at meridian varies with cosine of the latitude. This amount varies diurnally toward zero at sunrise and sunset. The long days of summer at high latitudes tend to offset the influence of the lower angle of incidence.

Birge and Juday (1921) using a thermocouple (bolometer) report that 5% of the sun's energy remains at 5 meters and about 1% at 10 meters. More refined results and very elaborate data are given in a later paper (Birge and Juday, 1929). In sea water Shelford and Gail (1922), using a photoelectric cell, found that about 10% of the light penetrating the surface remained at 10 meters. Klug (1925) using an instrument based on photographic emulsion found that 27% of the light which penetrated the surface remained at 5 meters and that 1.5% persisted at 10 meters. Shelford found 25% of the incident light reflected, Klug 33%.

From the above results it is evident that in our lakes whose transparency approximates that of the Wisconsin lakes, the epilimnion is well lighted and the thermocline receives light sufficient for photosynthesis especially in the upper half. In practically all our lakes the hypolimnion lies below 10 meters. From the results of Birge and Juday l. c. the hypolimnion never receives as much as one per cent of the incident solar energy.

#### *The Hypolimnion*

The hypolimnion is completely sealed from the air during the period of summer stagnation. It is cold and dark. This means that all the oxygen it has is that taken down with the water during the vernal circulation. This amount is gradually reduced. This reduction is due in part to the respiration of the organisms present, but usually the most important factor in its reduction is the decay of organic matter. There is always organic matter on the bottom of the lake. Its decay reduces the oxygen in a thin stratum of water in contact with it.

However, the organisms that live at and near the surface (in the epilimnion) die in large numbers and their remains slowly sink. As they pass through the lower strata of water, they slowly reduce the amount of oxygen. It is obvious that the rate of oxygen reduction depends on two factors, the amount of this organic matter present and the temperature of the water. The temperature of the water depends on the date of stratification. Some lakes stratify earlier than others and the same lake may stratify at different dates in different years.

Of the thirty-two lakes (excluding James and Snow), twelve had no oxygen at the bottom on the date examined. Seventeen others had less than 1 cc. per liter. Of the three that had an excess of 1 cc. per liter, two (Clear of Steuben and Crooked of Whitley County), are the deepest of the series, 32 and 30 meters respectively. Crooked of Whitley is cold on the bottom; its temperature, 6.1° C., is equaled only by Cedar of Whitley. Clear is moderately cold, 10.7° C., but is usually rather free from organic matter. Its littoral is especially free from plants. These two factors account for the persistence to mid-summer of considerable oxygen at the bottom.

Loon Lake on the other hand is the shallowest lake in the series. Its depth is only four meters. On the day the collection was made its surface temperature was 26.7 while the bottom was 21.4.

The temperatures clearly indicate that the lake is mixed to the bottom by the wind during the summer. A period of calm weather would rapidly reduce the oxygen in the lower layers because of the high temperature.

LAKE	Date	S	2	4	6	8
1. James N.	6-19	104	104	105	103	
2. James J.	6-20	108	104	106	102	
3. James L.	6-21	105	104	107	101	
4. James B.	6-21	103	104	103		
5. Snow.	6-22			100.7		
6. Snow.	6-22			100.4		
7. James A.	6-24	113	111	121	108	
8. James J.	6-24	112	110	116	108	
9. James D.	6-25	109	107	113	103	
10. James F.	6-25		107	113	102	
11. James I.	6-26	106	108	116	110	
12. James H.	6-27	106	104			
13. James K.	6-28		108	109	106	
14. James C.	7-1	115	118	115	107	
15. James E.	7-2	116	116	110	116	
16. James U.	7-2			114	104	
20. James M.	7-4			101		
22. Gage.	7-6					158
23. Fox.	7-10	106	106	102	123	
26. Hamilton.	7-11	122	122	105		
27. Center.	7-14		101			
28. Clear.	7-15	107	107	110	107	139
29. U. Otter.	7-17	108				
30. L. Otter.	7-18	106	106			
32. Hog.	7-23	106	102			
34. Silver.	7-24			100		
35. Hogback.	7-24	103				
39. Crooked.	7-30	103	103	103		
40. Hamilton.	7-31	106	115	103		
41. Marsh.	8-1	115	112			
42. George.	8-2	108	111	105		
44. Gage.	8-3					153
45. Clear.	8-5					134
50. James G.	8-8	100	102			
51. James I.	8-9	102	101	104		

TABLE No. 3. Oxygen supersaturations for the year 1929. All except those at 8 meters are in the epilimnion.

#### *The Thermocline (mesolimnion)*

The thermocline like the lower levels of the lake (hypolimnion) is sealed from the atmosphere during the period of stagnation but unlike the hypolimnion its temperature varies from that of the epilimnion above to that of the hypolimnion below. It often receives an appreciable amount of light. Its temperature facilitates both more rapid decay of organic material and more

rapid metabolism in the living organism than occurs in the cooler waters beneath it.

The result is that when few chlorophyll bearing organisms are present the oxygen is often reduced more in the thermocline than it is in the upper part of the hypolimnion. This produces what might be called the thermocline oxygen notch. It regularly develops in Tippecanoe Lake. In these studies I have found it in station N of James Lake, and in Station O in Snow Lake.

Birge and Juday (1911) report it for lakes North, Green, and Knights. Litynske (1926) found it in Lake Wigvy. Lake Plön and "Schöhsee" according to Thienemann (1928) develop this condition.

This deficiency of oxygen in the thermocline is always subsequent to the establishment of the summer stratification. It usually develops in August and lasts into September. The earliest recorded date I have been able to find is July 12 in Plön, Thienemann (l. c., p. 168). However, in this instance the amount at 15 meters is only .56 cc. per liter less than the amount at 20 meters.

The biological significance of this will be discussed in its relation to the cisco (*Argyrosomus arcti* cisco Jordan).

Occasionally a rather dense flora of diatom or algae develops in the thermocline. When this occurs the water may become highly super-saturated. A super-saturation in the thermocline is much more permanent than one developed in the epilimnion because the water of the thermocline is not exposed to the air.

For instance, a super-saturation was found in Otter Lake in 1909 at 4 meters on July 2. This was still present on July 17 and August 13 (Birge and Juday, 1911, Figures 59, 60, 61).

In these lakes Gage had a super-saturation of 158% at 8 M. on July 6. On this date the 5 to 10 meter level had 74,135 Lyngbya per liter. On August 3 the saturation at 8 meters was 153% although the amount of phytoplankton had declined. In Clear Lake the saturation on July 15 was 139% and on August 5 it was 134%. The super-saturation that develops in the thermocline may persist more than a month and for a considerable period after the decline of the plankton flora that produced it as the data in Gage indicated.

In general the oxygen in the thermocline may reach a minimum as low as that of the hypolimnion or it may have a maximum exceeding that of the epilimnion. In either case the condition is very persistent usually lasting until the sinking of the thermocline restores the circulation of the water with that of the epilimnion.

	June	July	August
1929:			
Hours.....	354.3	368.3	299.9
Mean percent.....	78.	80.	70.
Normal percent.....	67.	70.	66.
1930:			
Hours.....	332.9	351.7	215.1
Mean percent.....	74.	77.	50.
Normal percent.....	67.	71.	66.
Excess Hours 1929 over 1930.....	21.4	16.6	84.8

TABLE No. 4. Sunshine records from the monthly meteorological summary, Ft. Wayne station.

### *Epilimnion*

Oxygen in the epilimnion may change rapidly but rarely does the amount become excessively high or low. This region is influenced by the vicissitudes of the weather as well as the diurnal changes. When considerable phytoplankton is present a calm clear day will result in a super-saturation of oxygen. But a high wind will reduce this to about the saturation point.

Theoretically there should be a diurnal oxygen pulse in the epilimnion on clear days. This is, however, rarely detectable. Birge and Juday (1911, p. 43) found it in Mendota on September 21, 1908. It was demonstrated (Scott, 1923) on Winona Lake August 9, 1922. On Winona Lake it has been impossible to demonstrate this pulse except in very calm and clear weather.

However, even with slight breezes a super-saturation may be built up if there are successive days of sunshine. In 1929 there were 51 series of  $O_2$  determination. In these 51 series there were 32 super-saturations in the epilimnion or 62% of the series. In 1930 there were 7 super-saturations in 24 series or 29% of the total.

An increase of the oxygen above the saturation point in the epilimnion can only be accomplished by photosynthesis. This in turn depends on the number of phytoplanktonts and the number of hours of sunshine. The number of phytoplanktonts varied from lake to lake, but there was no appreciable difference between the two years.

The sunshine records were obtained from Fort Wayne. The U. S. Weather Bureau Station at Fort Wayne is the nearest station to this group of lakes. The lakes average about 40 miles from Fort Wayne. They are arranged roughly in an arc from north to north of west.

These data appear in Table No. 3. There was more sunlight in each of the summer months in 1929 than there was in 1930. In 1929 this excess amounted to 21.4 hours, 16.6 hours, and 84.8 hours in June, July, and August. In 1930 most of our work was done in August, the month of the greatest excess. The normal percent of sunshine for August is 66. The mean for August, 1930, was 50 while the mean for August, 1929, was 70. That is, there was approximately 40% more hours of sunlight at Fort Wayne in August, 1929, than there was in 1930.

There is evidence that records obtained at a station in the middle of a city differ from those taken in the open country. There is no evidence that this relation would vary from year to year.

The above data indicate something of the amplitude of seasonal variation in the epilimnion. How much this seasonal variation in photosynthesis and the consequent production of carbohydrates would affect the other life in the lake is unknown. It has been shown (Hjort, 1914 and others) that some marine fishes grow more rapidly one year than another. So far as I know this has not been clearly demonstrated for fresh water fish.

### THE PLANKTON

The plankton is one of the most important elements in the economy of a lake and one of the most difficult to evaluate. It has been measured volumetrically, numerically, and gravimetrically. The volumetric and gravimetric methods are relatively rapid, but neither permits analysis of the components of the plankton. Plankton is studied as a mass and not as an association of organisms. The volumetric method also has the well known difficulty arising from the fact that different planktonts settle at different rates.



By enumerating the different organisms it is possible to compare their relative abundance in different lakes and to determine their seasonal variations. The difficulty of this method is that neither the weight nor volume of any individual organism of the plankton is accurately known so that the weight or volume of plankton per unit cannot be calculated.

Another difficulty in evaluating plankton is that a few of the forms are probably end products, while many of them are not. The crustacea, especially the cladocera, eat the smaller phytoplankton and in turn are eaten by the fish. The number or amount present at a given time are those that have not been eaten or destroyed in some other way. The value of any organism is not a function of the number present at a given moment, but is a function of the reproductive capacity of this population.

LAKE	Number Daphnids sq. M. Max. Depth	Food Available for Number gms. of Fish sq. M.	Pounds of Fish Per Acre Possible
Golden.....	150,000	1,442	12,872
Hogback.....	209,000	2,009	17,811
Long.....	246,000	2,365	21,049
George.....	52,000	500	4,452
Clear.....	36,000	346	3,076

TABLE No. 5. The number of units of fish that the summer daphnid population will support. The first three lakes are especially rich in daphnids and are probably out of balance. The last two are poorer in daphnids and are probably more nearly balanced.

Banta (1921) reared *Daphnia* in an unbroken line from April, 1912, until September, 1916, nearly four and one-half years. He determined a reproductive factor by dividing the number of young in a brood by the time between broods. In the "minus" line, the reproductive factor was .99 and in his plus line it was 1.08. This means that on the average each parthenogenic adult produced approximately one young per day. If a population remains constant, an amount equally this population will be produced and eaten daily.

While it is not possible to convert any number of *Daphnia* into gravimetric or volumetric units, it is possible to convert these numbers into fish food requirements by experimental methods. This work was begun by Miss Blanche E. Penrod. By direct observation in an aquarium, she was able to determine the number of daphnids eaten by a blue gill in a given period of time; these periods varied from 15 minutes to one hour. The counts were recorded by a "tallying machine." The work is to be continued, but the results already obtained help in the interpretation of the plankton counts.

In 39 series, blue gills, each weighing 16 grams, ate on an average 139 daphnids per hour. We do not know just how many hours per day a blue gill feeds. If we assume that it feeds for 12 hours a blue gill weighing 16 grams would consume 1668 daphnids, or 104 daphnids per gram of fish.

If this amount is divided into the number of daphnids present in a given column of water (which equals its productive capacity), the quotient represents the number of grams of fish that the daphnids present on that date would support.

In Table 4, this has been computed. Golden, Long, and Hogback Lakes are shallow, rich lakes. George and Clear are relatively deep lakes, not

subject to such rapid changes in temperatures and biota as occur in the shallower lakes. The seasonal changes in daphnid populations are extreme. Especially is this true in shallow, rich lakes. The maxima occur during the spring, summer, or fall, when the fish feed most. The evidence from hatchery plants and from scale studies indicates that fish in inland waters feed little during the colder parts of the year. However, it is hardly likely that a lake would support a fish population indicated by the maximum daphnid population. The average for the warmer months would be a better basis for estimation.

It is also true that blue gills at times feed almost wholly on other organisms. In Wawasee Lake, Hile found them feeding at times almost wholly on chironomid larvae. When the seasonal variations in feeding are worked out, it may be that during daphnid minima, other foods make up the deficit. These questions must await further data.

Another bit of evidence that assists in this evaluation is some data on the contents of fish stomachs. During the studies of Dr. Hile on the fish scales, Mr. E. G. Thomas determined the contents of the stomachs of 412 fish of which 292 were blue gills. Of these blue gills, 138 had eaten daphnids. The work had to be done rapidly. The contents were fractionated and an aliquot part of the daphnids counted. Absolute accuracy was not attained but the results are a fair approximation. Some of the fish contained more daphnids than others. The average number per gram of fish for the 138 fish was 5.5. The maximum for a single fish was 26 daphnids per gram. This indicates that the estimate that daphnids may feed 12 hours per day is too high and consequently the estimate of the number of pounds of fish a lake will support is too low.

The food of the daphnids consists of the smaller forms in the plankton, the so-called nannoplankton. The amount of this that a daphnid requires is a rather difficult problem. The volume of the alimentary canal of *Bosmina*, *Daphnia pulex* and *Daphnia retrocurva* has been determined by making a model to scale and measuring this volume by water displacement. The volumes are .00109 cc., .00287 cc., and .00336 cc., respectively. Some data have been collected on the rate at which food passes through the alimentary tract of these forms. Although 144 readings have been made, some of the results are rather erratic. Consequently, they are withheld until the factors causing the variations are determined. It is hoped that this work will add one more link in the "food chains" in our lakes.

### JAMES LAKE—ITS PECULIARITIES

James Lake has the most complex basin of any lake whose map or description I have been able to secure. It has three major basins designated first, second, and third, beginning at the south. Snow Lake, lying to the north of the third basin, is really a fourth basin of Lake James, although the channel connecting the third basin and Snow Lake is longer, narrower, and shallower than the channels connecting the other basins. These four basins lie in a great crescent with the convex side to the west (see map). The first and second basins are connected by a channel 800 feet (242 M.) wide and 27 feet (8.2 M.) deep. The channel connecting the second and third basin is 500 feet (152 M.) wide and 30 feet (9.1 M.) deep.

These four primary basins have twenty-one secondary basins or deeps distributed as follows. The first basin has eight, the second five, the third three, the fourth (Snow) five. These secondary basins differ from each other physically, chemically, and biologically. In Table 6 I have selected five pairs that have the same depth. The bottom temperatures of the basins having the same depth differ from .5 degrees C. in basins N and O to 2.8 degrees in basins E and K. This indicates that the basins stratify on different dates. Those with the colder water at the same depth stratify first.

Two factors influence the rate at which oxygen is depleted from the bottom. The higher the temperature and the more organic matter present, the more rapidly the oxygen is reduced. In the pairs CU, BJ, and NO, the temperature is the more potent factor. In the basins GP and EK, the oxygen is lowest at the bottom in the basin of each pair that has the lowest temperature indicating that more organic matter or more easily oxidized material is present in the basin with the minimum temperature.

Date	Station	D	T	O	CO <sub>2</sub>	Cb
6-24.....	G	15	13.1	3.1	3.8	35.78
7-4.....	P	15	10.6	0	7.50	38.42
7-2.....	E	17	12.8	2.7	2.84	38.28
6-28.....	K	17	10.	1.3	7.52	31.82
7-1.....	C	18	11.7	1.5	4.90	39.30
7-2.....	U	18	10.0	4.1	4.12	38.78
6-21.....	B	20	11.7	2.0	1.38	39.18
6-21.....	J	20	9.2	2.6	1.64	38.42
6-19.....	N	25	6.7	2.3	3.52	38.92
6-22.....	O	25	7.2	0	7.70	42.42

TABLE 6. Comparison of Stations of the same depth in James Lake.

#### PLANKTON

Species	Sta.	0-5	5-10	10-15	15-20
Ceratium	N	2,448	332	284	11
	B	1,105	298	76	93
Dinobryum	N	19,051	288	136	21
	B	3,357	439	149	51
Daphnia	N	4.5	6	4	6
	B	8.	8.8	8.8	12.8
Holopedium	N	113	.....	.....	.....
	B	0	.....	.....	.....
Diaptomus	N	12	84	0	4
	B	8.8	4.8	14.4	10.4
Cyclops	N	13	64	.....	5
	B	21.6	3.2	7.2	5.6
Nauplii	N	19	64	.....	4
	B	42	29	4	29.6
Melosira	N	7,597	.....	231	217
	B	422	51	119	294
Fragillaria	N	9,525	5,040	1,752	1,203
	B	849	772	1,186	2,709
Clathrocyctis	N	11,680	204	.....	.....
	B	1,809	430	221	264

N—Depth 25 M.—date 6-19-29

B—Depth 20 M.—date 6-21-29

TABLE No. 7. Comparison of Stations N and B James Lake.

#### DISSOLVED GASES

D	T	O	%	CO	Cb
S	N	24.4	6.1	104	0
	B	24.2	6.0	103	— .25
20	N	7.3	4.8	.....	1.76
	B	2.	2.0	.....	.69
					19.46
					19.59

## LAKE: JAMES, STATIONS E AND U

Date: 7-2-1929—Aug. 1-18 M.

## PLANKTON

Species	E	U
Ceratum.....	1,194	610
Dinobryum.....	8	74
Aneura.....	52	35
Polyarthra.....	13	11
Notholca.....	20	9
Daphnia.....	1.7	3.7
Diaptomus.....	18	14
Cyclops.....	19	13
Nauplii.....	19	13
Melosira.....	210	158
Fragillaria.....	4,222	3,011
Asterionella.....	722	389
Anabena.....	4	.....
Clathrocyctis.....	56	37
Lyngbya.....	194	483

## DISSOLVED GASES

D	Temperature		Oxygen	
	E	U	E	U
S.....	22.2	22.1	7.1	.....
2.....	22.2	21.7	7.0	.....
4.....	22.2	21.1	7.1	7.1
6.....	18.9	16.4	7.0	7.07
8.....	14.7	13.9	6.8	6.7
10.....	13.7	12.8	5.7	6.2
12.....	13.3	11.1	4.3	5.5
15.....	13.1	10.2	3.7	4.3
17.....	12.8	10.	2.7	4.1

TABLE 8. Comparison of collections taken at stations of the same depth on the same date.

Not only do these basins differ in temperature and the distribution of gases, but the plankton is different. In Table 7 Stations N and B are compared. From the bottom temperatures, it is evident that Station N stratified later than Station B. Correlated with this is a much richer plankton in the former than in the latter. At Station N, Ceratium, Dinobryum, Melosira, Fragillaria, and Clathrocystus are strikingly more numerous than at Station B.

There are 113 Holopedium per liter at N, while it is entirely absent from Station B.

There are two days difference in the dates of the collections at these two stations.

The collections at Stations E and U were made on August 18. The differences here are quite apparent.

Ceratium, the rotifers, and all the phytoplankton were more numerous at E than U, while the reverse was true of Dinobryum and Daphnia.

In this case, as in Stations B and N, the station that had stratified later as indicated by the higher bottom temperature had developed the more plankton.

The epilimnion beyond the littoral is usually regarded as a rather homogeneous association. It appears from these data that it is homogeneous only because the thermocline and hypolimnion beneath it are homogeneous. Where these lower depths are separated by barriers they develop different characteristics. They differ in temperature, in oxygen, in carbonates, and probably in organic matter.

It seems apparent that the lower levels of a lake have a much more intimate relation and direct influence on the epilimnion during the summer stratification than has heretofore been suspected.

I first noted differences in temperature and dissolved gases in the different secondary basin of Webster Lake (Scott, 1916, p. 17). Welch (1927) has noted marked differences in the physical and chemical characteristics of the seven secondary basins of Douglas Lake.

The next problem is the analysis of the biological peculiarities of each basin and their relation to the physical and chemical characteristics of the basin. What influence one basin may have on another is entirely unknown.

### RELATION OF DISSOLVED OXYGEN AND CISCO

Early in September, usually between the first and tenth, the "cisco" (*Argyrosomus arcti cisco* Jordan) come to the surface of Snow Lake, struggle as if in discomfort, and then disappear. They have been described by local observers as "gasping for breath." When they begin to appear a maximum is soon reached, after which the number at the surface is rapidly reduced. The maximum rarely lasts more than a day and the whole phenomenon is over in less than a week. This has been observed on Snow Lake for at least thirty years. It occurs occasionally on the third basin of James Lake.

They have been examined repeatedly for parasites without success.

I suspected that the disappearance of the oxygen from the hypolimnion might be the cause.

In the fall of 1928 cisco were taken from Indian Village Lake, a small lake about four miles southeast of Lake Wawasee (Turkey Lake). A preliminary set of soundings indicated that its maximum depth was near six meters. It was possible that cisco taken in Indian Village Lake in November during the breeding "run" might have come from lakes farther up the chain. There are six lakes in the so-called Indian Village chain.

In 1929 a map was made of Indian Village Lake and the oxygen, carbonates, and temperature determined. The maximum depth was 6.4 meters. Only a trace of oxygen was found below 4 meters. Dr. Ralph Hile then set a 12 foot gill net in the deeper part of the lake, and took fish in the upper 2 feet only of the net.

The fish never appear at the surface except at the breeding, "run" in November.

Tippecanoe Lake develops an oxygen "notch" in the thermocline, but the oxygen in the hypolimnion is rarely, if ever, reduced to a level dangerous to the "cisco."

The evidence from Indian Village Lake indicates that the mere disappearance of the oxygen from the hypolimnion causes no discomfort if the oxygen curve maintains a simple sigmoid form. The development of a thermocline notch in the oxygen curve is not in itself dangerous. However, if there is a thermocline notch developed in the oxygen curve and subsequently the oxygen is exhausted from the lower hypolimnion, the fish will be forced upward by the latter process until they reach the lower part of the thermocline. From this level they move into a region of less oxygen by going either up or down. They are trapped and remain at this level until they approach asphyxia. When they lose control of their hydrostatic apparatus, they float

toward the surface. When this occurs in Snow Lake, they have 3 meters above them with little or no oxygen. This increases their discomfort. Although there is much oxygen in the upper 7 meters the fish float to the surface before they make a complete recovery.

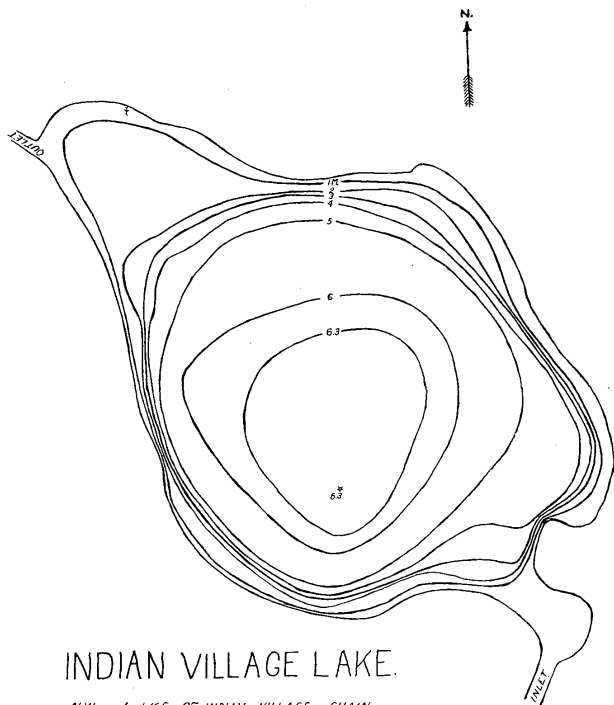


FIG. 2.

In Figure 3, the curve for Tippecanoe Lake has an oxygen notch with plenty of oxygen remaining in the hypolimnion. The curve for Indian Village Lake is a simple sigmoid curve. The curve for Snow Lake dated 9-7-30 shows the notch developed. In the curve for 9-14-29, the water is near oxygen saturation for the first 7 meters. At 8 meters there is approximately one-half as

much as at 7. At 9, 10, and 11 meters there is no oxygen but at 12 meters it appears again. This is the point just below the thermocline notch. So far high winds have prevented quantitative collections to demonstrate the accumulation of fish just below the thermocline notch. After they disappear from the surface they remain in the epilimnion. This has been demonstrated by netting. The other facts connected with this suggestion are well established.

For many years the fish have been gathered with dipnets in Snow Lake during the time when they come to the surface. With hand propelled craft they seem to have held their own. However, the increased use of the outboard motor has resulted in nearly every fish that reaches the surface during daylight hours being captured. The catch in 1929 and in 1930 is reported to be much below the normal. The present regulation should probably be modified in order that sufficient stock be preserved for breeding.

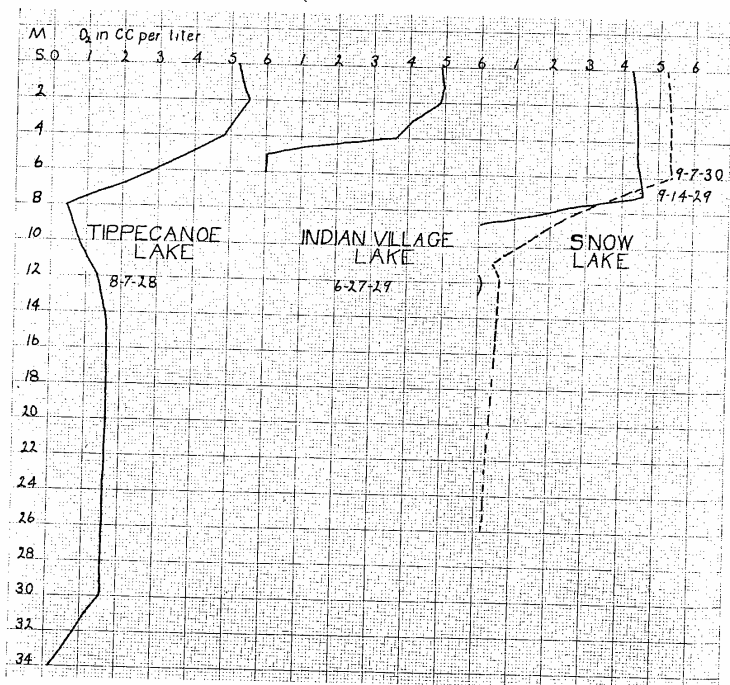


FIG. 3. Oxygen curves for Tippecanoe, Indian Village, and Snow Lakes.

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### EXPLANATION OF TABLES

The figures 0-5, 5-10, 10-15, and 15-20 are depth in meters.  
D—Depth. T—Temperature. O—Oxygen. %—Percent of saturation. CO<sub>2</sub>—Carbon-dioxide. Cb—Carbonates.

TABLE 9.  
LAKE: ADAMS (LaGrange)  
Date: 9/6/30

[illegible]

TABLE 10.  
LAKE: BIG CEDAR (LaGrange)  
Date: 9/2/30

[illegible]

TABLE 11.  
LAKE: BIG CEDAR (Whitley)  
Date: 8/12/30

Species	Plankton				Dissolved Gases					
	0-5	5-10	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Ceratium .....	4.2	8.5		12.8	8	26.1	5.38		-1.4	28.8
Dinobryum .....		4.2			2	25	5.35		-1.4	29.2
Aneura .....					4	24.4	5.69		-1.0	28.2
Noltholea		12.8	4.2		6	17.7	6.71		-1.4	29.2
Polyarthra	8.5	4.2			8	13.3	7.10		-1.4	31.8
Asplanena	4.2		8.5	12.8	10	10.3	5.97		-1.0	31.8
Hexarthra					12	8.8	4.57		.4	32.0
Daphnia	2.4	10.4	15	28.8	14	7.2	2.90		2.0	31.6
Diaptomus	5.6	16	.8							
Cyclops	3.2	14.4	14.4	11.2						
Nauplii	17	46.9	76	81						
Corethra		21	4.2		21.5	6.1	40		2.0	31.6
Melosira		4.2								
Fragillaria	25	25	64	110						
Asterionella		12.8	59	42						
Anabena	68	136	29	29						
Clathrocyctis	21	298	89	153						
Oscillatoria		8.5	4							
Lyngbya	12.7	119	21	12						

TABLE 12.

LAKE: CENTER  
Date: 7/14/29

[illegible]

TABLE 13.  
LAKE: CENTER  
Date: 8/3/29

[illegible]

TABLE 14.

LAKE: CROOKED (Steuben)

Date: 7/5/29

[illegible]



Plankton

### Dissolved Gases



TABLE 17.  
LAKE: CLEAR (Steuben)  
Date: 7/15/29

[illegible]

TABLE 18.  
LAKE: CLEAR  
Date: 8/5/29

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	320	72	25	8	8	22.2	5.65		— .98	24.40
Dinobryum	4				2	22.2	5.82		— .98	23.90
Aneura	76	32	21	17	4	22.	5.88		— .74	24.40
Polyarthra			4		6	21.7	5.79		— .74	24.14
Noltholea	.8			4	8	14.7	9.38	134	— 1.74	26.38
Daphnia	1.6	4	1.6	3.2	10	12.5	4.25		2.98	27.38
					12	11.7	2.44		3.48	27.62
					15	10.9	1.60		4.22	28.38
Diaptomus	2.4	16.8	15	8.8						
Cyclops	6.4	10.4	5.6	5.6						
Nauplii	16.8	10.2	11	5.6	20	10.6	1.19		4.72	27.38
Melosira	68	12	46	128						
Fragillaria	46	17	17	12	25	1.6	.70		4.98	28.62
Asterionella										
Anabena	106	25	8							
Clathrocycetis	3,200	473	273	93	30		.08		5.72	28.18
Oscillatoria	153	136	102	68	32	10.4				
Lyngbya	537	1,036	209							

TABLE 19.  
LAKE: FOX  
Date: 7/10/29

[illegible]

TABLE 20.  
LAKE: GAGE  
Date: 7/6/29

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	477	128	140	46	8	22.2	5.9		.98	28.86
Dinobryum	1,710	46	499	72	2	22.2	5.9		.48	28.60
Aneura	8	38	42		4	20.9	6.1		.48	28.60
Hexarthra	29	4.2	17	4.2	6	20.6	6.0		.48	28.60
Polyarthra	25	42	34	17	8	14.4	11.2	158	2.98	28.86
Noltholca	21			4.2	10	12.5	4.3		2.48	29.34
Asplanena					12	11.5	4.0		4.96	30.34
Daphnia	13	5.6	.8	.8	15	10.9	.03		4.46	31.48
Bosmina	1.6									
Diaptomus	36	4.8	1.6							
Cyclops	16	24	3.2	1.6						
Nauplii	55	12.8	4		21.5	10.6	0		5.46	31.48
Corethra		1.6	.8							
Melosira	157	4	55	25						
Fragillaria	857	170	392	157						
Asterionella	106		17	4.2						
Anabena	42	12								
Clathrocycetis	1,608	302	226	38						
Oscillatoria										
Lyngbya	1,220	74,133	1,933	200						

TABLE 21.  
LAKE: GAGE  
Date: 8/3/29

Plankton					Dissolved Gases						
Species	0-5	5-10	10-15	15-20		D	T	O	%	CO <sub>2</sub>	Cb
Ceratium		153.6	51	51		8	24.4	5.31		0	26.64
Dinobryum		332.8	332	92		2	24.4	5.16		0	27.63
Aneura		45	10	15		4	23.9	5.17		0	26.89
Polyarthra						6	20.4	5.05		0	27.39
Noltholca		81.9	20	5		8	15	10.64	153	-1.24	24.65
Daphnia		7.6				10	12.8	1.31		3.98	29.88
Asplanena		35				12	11.7	.27		5.00	30.37
Diaptomus		.9		.9		15	11.1	0		4.98	30.87
Cyclops		4.8	8	.9							
Nauplii		29.4	5	.9							
Corethra		2	5			21	10.6	0		8.46	39.54
Melosira		225	122	9.2							
Fragillaria		40	5	20							
Asterionella		35									
Anabena		5									
Clathrocyetis		97	302	97							
Oscillatoria				5							
Lyngbya		43,950	936	424.9							

TABLE 22.  
LAKE: GEORGE  
Date: 7/8/29

## Plankton

## Dissolved Gases

Species	0-5	5-10	10-15	15-20		D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	2,056	413	59	8		8	23.35	5.7			30.60
Dinobryum	93	17	4			2	23.1	5.7			28.86
Aneura	8.5	4.2				4	23.0	5.7			28.60
Noltholca		8.5									
Polyarthra						6	21.1	5.4			29.34
Asplanchna	8.5										
Hexarthra	34	4.2				8	15.9	4.2		1.76	31.94
Daphnia	1.6	9.6	23	6		10	13.9	4.1		3.22	32.34
						12	12.5	3.2		2.72	30.60
						15	12.0	2.0		5.96	33.32
Diaptomus	17	12	3								
Cyclops	3.2	2.4	4.8	2							
Nauplii	34	8	17	3		20	11.1	1.2		4.26	33.32
Corethra		1									
Melosira	55	25	85	64							
Fragillaria	1,373	149	136	17		25	11.1	.93		5.46	33.08
Asterionella	34	8	29.8	4							
Anabena											
Clathrocyctis	469	597	213	123							
Oscillatoria	110	51	21	17							
Lyngbya											
Spir	21	8	8								

TABLE 23.  
LAKE: GEORGE  
Date: 8/2/29

[illegible]





TABLE 25.  
LAKE: HAMILTON  
Date: 7/11/29

[illegible]

TABLE 26.  
LAKE: HAMILTON  
Date: 7/31/29

[illegible]

TABLE 27.  
LAKE: HOG  
Date: 7/23/29

Species	Plankton				Dissolved Gases					
	0-5	5-9	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	1,058	268			8	26.6	5.98	106	0	27.80
Dinobryum	4,151	529			2	26.6	5.76	102	0	28.24
Aneura	8				4	23.9	6.25	106	0	28.60
Polyarthra	51	25			6	19.4	5.21		3.40	31.32
Asplanena	128	21			9	13.3	.34		6.62	38.54
Hexarthra	5.6	4.8								
Daphnia										
Diaptomus	6.4	4.8								
Cyclops	12	4.8								
Nauplii	24.8	28								
Melosira	17	12								
Fragillaria	2,124	419								
Asterionella		8								
Anabena		4								
Clathrocystis	1,356	435								
Oscillatoria										
Lyngbya		268								

Date: 7/24/29

### Dissolved Gases



TABLE 30.  
LAKE: JAMES, Station B.  
Date: 6/21/29

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	1,105	298	76	93	8	24.2	6.0	103	— .50	37.40
Dinobryum	3,357	439	149	51	2	23.9	6.1	104	— .74	36.90
Aneura	42	4.2	17	49	4	21.4	6.3	103	— .74	36.40
Hexarthra			4.2		6	16.9	6.4		— .50	37.66
Polyarthra				4.2	8	14.4	6.1		0	37.40
Notholea	8	12.8	4	4.8						
Triarthra		8.5	1.6	12	10	14.2	5.8		1.50	38.42
Asplanena				4.2						
Daphnia	8	8.8	8.8	12.8	12	13.3	4.7		.50	37.66
					15	13.1	4.0		.62	37.92
Diaptomus	8.8	4.8	14.4	10.4						
Cyclops	21.6	3.2	7.2	5.6	20	11.7	2.0		1.38	39.18
Nauplii	42	29	4	29.6						
Melosira	422	51	119	294						
Fragillaria	849	772	1,186	2,769						
Asterionella	273	435	362	593						
Anabena										
Clathrocyetis	1,809	430	221	264						
Oscillatoria	38	55	221	12						
Lyngbya	558	98	72	25						

TABLE 31.  
LAKE: JAMES, Station I.  
Date: 6/26/29

Species	Plankton				Dissolved Gases						
	0-5	5-10	10-15	15-20		D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	2,321	422	179	51		8	23.3	6.3	106	1.21	35.76
Dinobryum	977	166	17	21		2	23.3	6.4	108	.98	35.76
Aneura	38	17	38	51		4	20.6	7.2	116	.72	35.76
Polyarthra						6	16.7	7.4	110	0	36.0
Noltholca	12	8	8			8	13.9	6.9		.98	36.50
Triarthra	4		8	21		10	12.8	5.9		2.20	36.50
Hexarthra	4	4	8			12	11.7	4.8		4.40	37.91
Daphnia	20	4	7.2	8		15	10.3	5.4		3.42	36.74
Diaptomus	15	11	10	4.8		20	8.9	2.6		4.90	37.24
Cyclops	82	6	9	4.8		22	8.9	1.5		5.62	37.24
Nauplii	11	34	6	11.2							
Corethra		.8	2								
Melosira	64	68	102	435							
Fragillaria	2,180	1,326	1,258	2,112							
Asterionella	256	422	170	136							
Anabena											
Clathrocyctis	5,491	1,160	516	733							
Oscillatoria	81	64	8.5	46							
Lyngbya	226	631	388	51							





TABLE 33.  
LAKE: JAMES, Station U.  
Date: 7/2/29

[illegible]

TABLE 34.

LAKE: JAMES, Station M.

Date: 7/4/29

[illegible]

TABLE 35.  
LAKE: JAMES, Station N.  
Date: 8/6/29

[illegible]



TABLE 37.  
LAKE: JAMES, Station B.  
Date: 8/7/29

Species	Plankton				Dissolved Gases					
	0-5	5-10	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	435	256	68	42	8	22.5	5.70		0	34.98
					2	22.2	5.94		0	34.22
Dinobryum	12				4	22.2	5.33		0	33.86
Aneura	85	25	8.5	8.5	6	21.4	5.51		0	34.48
Hexarthra		12.8			8	16.1	4.43		3.98	38.08
Polyarthra	4		4.2		10	13.9	2.35		4.72	39.08
Noltholca					12	13.3	1.34		4.98	38.08
Triarthra					15	13.3	.58		6.22	38.34
Daphnia	4	3.2			20	12.2	.09		6.22	39.58
Diaptomus	7	8.8	10	.8						
Cyclops	8	7.2	5.6	1.6						
Nauplii	34	29	4	.8						
Corethra			4							
Melosira	68	25	17	12.8						
Fragillaria	209	285	72	119						
Asterionella										
Anabena										
Clathrocystis	563	742	247	226						
Oscillatoria	64	42	21	46						
Lyngbya	59	90	8	17						

TABLE 38.  
LAKE: JAMES, Station J.  
Date: 8/8/29

Plankton					Dissolved Gases						
Species	0-5	5-10	10-15	15-20		D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	465	200	51	12		8 2	22.8 22.8	5.99 6.09	100 102	0 0	34.60 33.10
Dinobryum	12		4			4	22.5	5.68		0	33.36
Aneura	42	8	8	17		6	20	5.35		0	33.86
Polyarthra						8	15.6	4.32		.24	33.84
Noltholea	4.2		4	8							
Hexarthra	4.2					10	13.1	3.68		4.72	38.58
Daphnia	14.4	4	.8	14		12	11.9	2.97		4.48	37.84
						15	10.3	2.70		6.72	37.34
Diaptomus	13	9.6	4.8	8							
Cyclops	32	6.4	6.4	5.6		20 21					
Nauplii	16	4.8	2.4	2.4			8.9	.13		7.96	39.58
Melosira	68	8	46	64							
Fragillaria	196	149	55	81							
Asterionella	8	4									
Anabena	29										
Clathrocyetis	435	1,181	516	554							
Oscillatoria	776	25	25	17							
Lyngbya	12	25	17	17							
Synedra			17	4							



TABLE 40.

LAKE: JAMES, Station N.

Date: 8/14/30

[illegible]



TABLE 41.  
LAKE: JAMES (3rd Basin)  
Date: 8/22/30

Species	Plankton				Dissolved Gases						
	0-5	5-10	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb	pH
Ceratium	1,032	204	145	145							
Mallomonas	140	17	17		S	22.2	5.71		—1.4	34.4	8.3
Dinobryum	34	12	21		2	22.2	5.80		—2.0	34.6	8.3
Uroglea	89	29		8	4	22.2	5.92		—1.4	34.0	8.3
Aneura	68	46	29	46	6	22.2	5.83		—2.0	33.8	8.3
Diffugia	138		17	25	8	15.2	5.61		.4	35.8	7.8
Polyarthra	21	4			10	11.6	2.90		.6	40.4	7.6
Noltholca	12		21	34	12	9.4	2.72		1.0	41.0	7.6
Daphnia	4.8	1.6	2.4	10.4							
Diaphanosoma	2.4	2.4		3.2	15	7.9	2.11		1.6	40.4	7.5
Diaptomus	27	7.2	8.8	14							
Cyclops	25	26.4	12.8	18.4	20	7.2	2.45		2.0	40	7.5
Nauplii	56	11.2	23.2	26.4							
Melosira	174	76	136	140							
Fragillaria	840	282	187	174	25	6.2	.06		2.4	41.4	7.2
Asterionella											
Anabena	46	8.5	4								
Clathrocyctis	465	541	401	264							
Oscillatoria	106	17	25	128							
Lyngbya	132		46	81							

TABLE 42.  
LAKE: JAMES (3rd Basin)  
Date: 8/30/80

[illegible]

TABLE 43.  
LAKE: JAMES (3rd Basin)  
Date: 9/7/30

Species	Plankton				Dissolved Gases					
	0-5	5-10	10-15	15-25	D	T	O	%	CO <sub>2</sub>	Cb
Uroglea	691	81								
Ceratium	1,484	328	106	145	S	22.2	5.88		-1.6	33.4
Dinobryum	55	29	4		2	22.2	6.11	101	-1.6	34.2
Mallomonas	110	34	17.1	21	4	22.2	6.06	100	-2.4	32.8
Aneura	85	8	4.2	59	6	21.6	5.82		-2.4	32.8
Polyarthra		38	17.1	12	8	16.1	3.70		0	35.6
Triarthra	12.8	8	8.5	8	10	11.6	2.10		.4	37.0
Notholca					12	10	1.95		1.4	39.6
Daphnia	4	1.6	7.2	6.2	15	8.0	1.76		1.4	41.0
Bosmina	2.4	.8	12.8	.8	20	6.9	1.72		2.0	42.0
Diaphanosoma					25	6.6	.07		2.4	42.0
Diaptomus	4.8	8								
Cyclops	16.8	9.6	8	5.6						
Nauplii	21.6	10.8	12.8	9.6						
Melosira	85	72	81	85						
Fragillaria	1,766	814	405	192						
Asterionella										
Anabena	354	25	46							
Ciathrocyetis	98	477	106	264						
Oscillatoria	106	72	72	46						
Lyngbya		166								

TABLE 44.  
LAKE: JAMES (3rd Basin) N.  
Date: 9/20/30

Plankton					Dissolved Gases						
Species	0-5	5-10	10-15	15-20		D	T	O	%	CO <sub>2</sub>	Cb
Diffugia	59	17	17								
Ceratium	704	311	81	76		8	21.1	5.11		-1.25	33.4
Uroglea	302	38	12	8							
Dinobryum	132	46	17	30		2					
Mallomonas	21	33	25	8							
Aneura	81	61	34	38		4					
Polyarthra	34		12			6	20.5	5.56		0	33.4
Notholca	4.2			8		8	16.3	4.21		1.0	34.8
Asplanchna	4.2					9	13.8				
Daphnia	.8	.8	2.4	2.4		10	12.2	1.19		7.10	50.4
Bosmina		.8				12	9.4	1.10		1.50	40.0
Diaphanosoma		1.6									
Diaptomus	.8	13.6	4	4		15	8	1.61		3.02	40.4
Cyclops	7.2	14.4	9.6	3.2							
Nauplii	14.4	13.6	14.4	8		20	7.0	1.55		3.02	40.4
Melosira	64	38	38.4	30.8		24.5	6.6	.12		4.06	41.8
Fragillaria	1,339	1,651	494	264							
Asterionella											
Anabena	21		8.5								
Clathrocyetis	252	512	166	187							
Oscillatoria	140	93	17	30							
Lyngbya	115	106	57								

TABLE 45.  
LAKE: JIMMERSON  
Date: 7/19/29

Species	Plankton				Dissolved Gases					
	0-5	5-10	10-17	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	2,205	588	76		8	24.4	5.57		0	33.10
Dinobryum	302	46	4		2	24.4	5.57		0	32.62
Aneura	247	51	8		4	24.2	4.53		0	32.38
Polyarthra		12	4		6	17.2	4.99		2.70	34.10
Noltholca	4.2		8		8	13.9	3.26		2.70	37.56
Asplanchna	59	29			10	12.2	1.77		4.94	39.54
Hexarthra	6.4	6	2.4		12	11.1	.47		6.92	38.54
Daphnia	.8				17	10	.06		5.68	39.56
Bosmina										
Diaptomus	8	33								
Cyclops	21.6	14	1.6							
Nauplii	46	34	4.8							
Corethra	.8									
Melosira	136	136	85							
Fragillaria	3,200	1,557	242							
Asterionella	55	29	12							
Anabena	8	8								
Clathrocystis	682	576	614							
Oscillatoria	72	21	17							
Lyngbya	115	413	136							

TABLE 46.  
LAKE: LONG (Steuben)  
Date: 7/25/29

Plankton					Dissolved Gases					
Species	0-5	5-9	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	1,493	362			8	24.4	5.33		4.18	47.72
Dinobryum	435	119			2	21.9	5.24		5.40	48.94
Aneura	119	29			4	17.2	1.16		7.04	49.44
Polyarthra					6	14.4	.11		11.56	47.46
Noltholea	29	12								
Hexarthra	4	4			8					
Daphnia	48	1.6			9.5	12.2	0		15.74	57.06
Diaptomus	14	1.6								
Cyclops	24	2.4								
Nauplii	68	10								
Melosira	10,146	2,986								
Fragillaria	4,072	3,566								
Asterionella	4,962	4,232								
Anabena										
Clathrocyctis	170	64								
Oscillatoria										
Lyngbya	998	208								



TABLE 48.  
LAKE: LONG LAKE (N. Basin)  
Date: 8/20/30

Plankton					Dissolved Gases						
Species	0-5	5-10	10-18	15-20		D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	51	34	8			S	23.8	4.43		—1.0	23.2
Dinobryum	209	4,364	665			2	23.8	4.51		—2.4	23.2
Aneura	8	4				4	23.5	4.43		—2.4	23.2
Polyarthra		4.2				6	21.3	4.85		—1.4	23.2
Hexarthra	8										
Noltholea	8		4			8	13.3	1.95		.4	30.4
Daphnia	6.4	19	2.4			10	10.5	.35		1.2	29.8
						12	10	.17		1.0	30.8
Diaptomus	37	12				15	9.4	.05		.6	30.8
Cyclops	15	52	6.4			18	8.8	.05		1.4	32.2
Nauplii	55	115	2.4								
Melosira	4	64	17								
Fragillaria	4	4									
Asterionella											
Anabena	170	81	8								
Clathrocyetis	4,535	2,905	401								
Oscillatoria	89	76	25								
Lyngbya	341	746	17								



TABLE 49.  
LAKE: LONG LAKE (S. Basin) (LaGrange)  
Date: 8/20/30

Species	Plankton				Dissolved Gases						
	0-5	5-10	10-15	15-21	D	T	O	%	CO <sub>2</sub>	Cb	pH
Ceratium	140	42	8.5	2	S	23.8	5.03		—1.6	23.8	8.3
Dinobryum	311	759	657	106	2	23.8	5.15		—1.6	22.6	8.3
Aneura		8.5			4	23.5	5.13		—1.2	23.2	8.3
Polyarthra					6	21.6	4.51		—1.0	23.6	8.3
Asplanchna	4			4	8	12.7	1.53		1.0	29.6	7.5
Notholca					10	10.5	.31		1.0	29.8	7.1
Daphnia	8	.8	12	1.6	12	10	.34		2.0	29.8	7.1
Leptodera	.8				15	9.0	.08		2.0	30.2	7.1
Diaptomus	16	4	1.6	.8	22	8.8	.005		2.2	31.2	7.1
Cyclops	24	18	12	1.6							
Nauplii	98	55	23	1.6							
Melosira	8	21	17								
Fragillaria	38	12	85	4							
Asterionella											
Anabena	234	55	12								
Clathrocyctis	3,549	1,267	652	251							
Oscillatoria	123	38	34	25							
Lyngbya	311	499	136	25							

TABLE 50.

LAKE: OLIVER (LaGrange)

Date: 9/6/30

[illegible]

TABLE 51.  
LAKE: LOWER OTTER  
Date: 7/18/29

[illegible]



TABLE 53.  
LAKE: PLEASANT LAKE  
Date: 7/23/29

Species	Plankton				Dissolved Gases					
	0-5	5-10	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	136	21			S	25.6	5.57		0	24.96
Dinobryum					2	25	5.42		0	25.06
Aneura					4	23	5.74		0	24.38
Polyarthra					6	22	4.60		1.80	24.50
Noltholca	1.6	4			8	17.2	.37		4.98	27.24
Hexarthra	12.8	4			10	14.4	.09		4.54	28.60
Daphnia	25	2.4								
Diaptomus	32	.8								
Cyclops	4	2.4								
Nauplii	38	29								
Melosira		12								
Fragillaria	81	25								
Asterionella		12								
Anabena										
Clathrocystis	1,472	247								
Oscillatoria	17	12								
Lyngbya	17	42								

TABLE 54.  
LAKE: PRETTY  
Date: 8/18/30

Species	Plankton				Dissolved Gases					
	0-5	5-10	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Ch
Ceratium	2,948	102	72	128	S	23.8	5.18		-2.4	26.8
Dinobryum	1,966	42	25	34	2	23.8	5.24		-1.4	27.6
* Aneura	106	68		25						
Hexarthra	264	12	4	5.6	4	23.3	5.16		-1.6	27.8
Polyarthra	17	12.8	4.2		6	21.8	4.64		- .8	27.8
Noltholca	8.5	1.6	8.5	8	8	14.7	1.62		.4	32.2
Asplanena	21	8.5								
Daphnia	12	3.2	1.6		10	10	.85		1.0	33.0
					12	9.4	.45		1.0	32.6
					15	8.8	.35		1.0	31.8
Diaptomus	44	4	2.4	.8						
Cyclops	18	12	3.2	1.6						
Nauplii	332	50	10.4	4	20	8.3	.03		1.0	32.2
Melosira	12	29	21	17	24.5	8.3	.04		1.0	31.8
Fragillaria	4,083	334	162	98						
Asterionella	4	4		4.2						
Anabena	42			4						
Clathrocystis	563	742	115	102						
Oscillatoria	132	29	12	4						
Lyngbya	25	1,036	55	81						

TABLE 55.

LAKE: ROUND

Date: 8/12/30

Species	Plankton				Dissolved Gases					
	0-5	5-10	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	243	46	4.2		8	25	5.05	0	-1.0	22.4
Dinobryum	25.6				2	24.4	5.44		-1.0	21.6
Aneura	17	4.2			4	23.6	5.03		-1.4	21.6
Polyarthra					6	20.5	4.90		.4	21.2
Asplanena	21				8	13.8	.24		3.0	28.8
Hexarthra	42	12.8			10	10.5	.335		3.0	28.8
Daphnia	7.2	1.6	1.6							
Bosmina		.8								
Diaptomus	14.4		.8							
Cyclops	20.8	3.2	.8							
Nauplii	68.2	25.6			18	9.4	.0		3.0	31.2
Melosira	38.4	38.4	64							
Fragillaria	2,517	409	132							
Asterionella		4.2								
Anabena	755	55	17							
Clathrocyetis	729	554	204							
Oscillatoria	98	25	85							
Lyngbya	17,937	742	593							

TABLE 56.  
LAKE: SHRINER  
Date: 8/15/30

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	C <sub>g</sub>	CO <sub>2</sub>	Cb
Ceratium	4	12	1		8	26.6	5.25		-1.4	23.6
Dinobryum	17	25 2,201	4 42		2	25.3	5.32		-1.0	24.2
Aneura			.8		4	25	5.33		-1.4	24.2
Noltholca										
Polyarthra		38			6	19.6	5.29		-1.2	23.6
Triarthra			2.4							
Hexarthra	17				8	12.7	6.63		0	26.2
Asplanena		4								
Daphnia	14	24	4.8		10	10.5	2.39		1.0	26.8
					12	7.77	1.23		2	26.8
					15	8.8	.14		2	27.6
Diaptomus	6.4	52	8		18	8.6	.06		3.0	28.0
Cyclops	1.6	19	2.4							
Nauplii	34	25	10							
Corethra		4								
Melosira		25	25							
Fragillaria	418	209	46							
Asterionella										
Anabena	132	277	34							
Clathrocycetis	341	725	358							
Oscillatoria	8		405							
Lyngbya		2,926	59							



TABLE 57.

LAKE: SILVER

Date: 7/24/29

Plankton					Dissolved Gases					
Species	0-5	5-11	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	315	55			8	25	5.15		0	26.22
Dinobryum	264	64			2	24.7	5.06		0	26.54
Aneura	21				4	23.1	4.94		0	26.78
Polyarthra					6	17.7	.22		4.88	31.32
Noltholea	25				8	13.9	.10		6.34	31.32
Hexarthra	8	4			10					
Asplanena		4			11	11.7	.0		8.16	36.08
Daphnia	12									
Diaptomus	9.6	1.6								
Cyclops	4	.8								
Nauplii	47	4.2								
Melosira	140	217								
Fragillaria	102	17								
Asterionella	704	119								
Anabena	8									
Clathrocycetis	768	341								
Oscillatoria	140	34								
Lyngbya	17	320								

TABLE 58.  
LAKE: SNOW, Station O.  
Date: 6/22/29

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	640	55	42	38	8	24.7	5.6		.74	36.92
Dinobryum	38	8.5	4	4.2	2	24.2	5.6		.74	36.40
Aneura	72	4.2	12	17	4	19.4	6.4	100.7	.60	38.42
Hexarthra	21	4.2								
Polyarthra					6	15.6	5.5		.50	38.42
Noltholea	12	17	17	4.2						
Asplanena	12	4.2	4	12.8	8	13.7	4.9		.74	38.42
Daphnia	10	4	2.4	1.6	10	12.2	4.1		1.50	38.92
					12	11.1	3.7		2.26	38.66
					15	10.6	3.1		2.62	38.92
Diaptomus	13	22	5.6	1.6						
Cyclops	37	3.2	1.6	.8						
Nauplii	44	25	25	10	20	8.3	.15		3.02	37.92
Melosira	529	469	725	1,821	25	7.2	0		6.66	40.44
Fragillaria	733	297	460	384						
Tabellaria			110							
Asterionella	85	98	34	140						
Anabena	17	8								
Clathrocystis	2,444	439	640	145						
Oscillatoria	157	17		12						
Lyngbya	315	34	59	46						

TABLE 59.  
LAKE: SNOW, Station Q.  
Date: 7/3/29

[illegible]

TABLE 60.  
LAKE: SNOW, Station S.  
Date: 7/3/29

[illegible]

TABLE 61.  
LAKE: SNOW, Station P.  
Date: 7/4/29

[illegible]

TABLE 62.  
LAKE: SNOW, Station O.  
Date: 8/6/29

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	840	106	51	34	8	22	5.50			36.34
Dinobryum	516	12	8	12	2	22	5.49			35.34
Aneura	76	17	38		4	22	5.43			35.34
Asplanchna			4		6	18.2	3.69		3.48	36.34
Polarthra	4.2	4			8	13.7	2.69		3.98	38.34
Noltholca	4.2				10	12	2.12		6.96	37.58
Hexarthra				1.6	12	11	1.99		5.22	38.84
Daphnia					15	10.6	1.68		5.46	39.34
Diaptomus	5.6	4	3.2	3.2						
Cyclops	12.8	9.6	1.6	1.6						
Nauplii	16	8	1.6	5.6	20	8.6	.97		6.22	38.84
Corethra	42		1.6							
Melosira	183	213	72	38	25	7.5	.06		7.70	42.42
Fragillaria	435	226	157	320						
Asterionella	4	8	8							
Anabena	25									
Clathrocyctis	686	297	401	234						
Oscillatoria	115	29	42	38						
Lyngbya	64	149	12	8						

TABLE 63.  
LAKE: SNOW LAKE  
Date: 8/14/30

[illegible]

TABLE 64.  
LAKE: SNOW LAKE  
Date: 8/22/30

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Ceratium	1,877	337	127	38	8	22.2	5.03		— .60	13.80
Acinetætes		213	81		2	22.2	5.69		—2.4	34.8
Dinobryum	1,838	349	89	17	4	22	5.99		—2.0	35.2
Aneura	128	38	17	12	6	21.2	5.92		—1.4	35.4
Triarthra	8	25			8					
Polyarthra	179	68	34		10	9.8	2.51		1.4	42.0
Asplanchna	12			2	12	8.9	1.47		2.0	42.2
Noltholca	4				15	8.3	1.23		1.4	42.0
Daphnia		2.4	3.2	8						
Diaptomus		9.6	4.8	8.8						
Cyclops	23	32	5.6	4						
Nauplii	36	14.4	4.8	17	20	7.2	1.11		2.4	41.4
Corethra				.8						
Melosira	115	64	162	115	24.5	6.6	.09		3.0	44.0
Fragillaria	366	123	123	25						
Asterionella										
Anabena	46	89		12						
Clathrocyctis	17,412	3,468	806	302						
Oscillatoria	456	221	93	162						
Lyngbya		75	119							



TABLE 65.  
LAKE: SNOW LAKE  
Date: 8/30/30

Species	Plankton				Dissolved Gases						
	0-5	5-10	10-15	15-24	D	T	O	%	CO <sub>2</sub>	Cb	pH
Ceratium	341	345	64	21	8	22.7	6.50	108	-1.4	35.0	8.3
Dinobryum	180	196	132	21	2	22.8	6.47	108	-2.2	35.2	
Aneura	42	25	4		4	22.2	5.91		-2.4	34.4	
Polyarthra	52	46	8.5		6	20.6	4.85		0	45.8	
Daphnia					8	12.2	2.50		1.4	44.0	
		2.4	6		10	9.5	1.60		2.0	41.6	
					12	8.8	1.10		1.4	42.6	
					13	8.3	.95		1.4	43.8	
Diaptomus	10	6.4	8	1.6							
Cyclops	36	16	4								
Nauplii	24	49	4.8		20	7.2	.92		3.4	43.0	
Melosira	25	30	68	4							
Fragillaria	217	320	64	17	24.5	6.6	.05		3.4	45.4	7.5
Asterionella											
Anabena	8	12									
Clathrocystis	5,004	1,612	935	614							
Oscillatoria	324	345	196	59							
Lyngbya	55	1,207	72								

TABLE 66.  
LAKE: SNOW LAKE  
Date: 9/2/30

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-24	D	T	O	%	CO <sub>2</sub>	Cb
Diffugia	38	17	8							
Ceratium	1,400	469	200	55	8	20.2	5.40		0	35.8
Uroglea	247	12								
Dinobryum	1,156	204	85	42	2					
Mallomonas	836	162	38		4					
Aneura	153	38	29	25						
Polyarthra	102	8			6	20	5.44		0	35.8
Triarthra	21				7	18.3				
Noltholca		4.2			8	16.3	2.70		-1.50	36.8
					9	11.1	.42		3.02	41.4
Daphnia	.8			5.6	10	10	.63		4.52	41.8
Bosmina	.8				12	9.4	.42		3.02	41.8
					15		.11		4.02	42.4
Diaptomus	.8	12	3.2	1.6						
Cyclops	12.8	55	12.8	11.2						
Nauplii	16.8	27	8	8.8	20		.06		4.52	42.4
Corethra				1.6						
Melosira	128	115	81	89	24.5	6.7				
Fragillaria	7,436	1,416	430	17						
Asterionella										
Anabena	238	149		4						
Clathrocycetis	1,587	473	1,320	115						
Oscillatoria	793	349	45	16						
Lyngbya	499	281	13	76						

TABLE 67.  
LAKE: SNOW LAKE  
Date: 9/7/30

Plankton					Dissolved Gases					
Species	0-5	5-10	10-15	15-20	D	T	O	%	CO <sub>2</sub>	Cb
Diffugia			4.2	17						
Ceratium	1,011	456	123	30	8	22.2	5.45		—1.4	33.8
Uroglea	951	217	6.4	1.7					—3.2	34.2
Dinobryum	399	81	17	4.2	2	21.6	5.58		—1.4	33.8
Mellomonas	512	55	55	12	4	21.9	5.40		— .4	34.8
Aneura	179	12.8		8.5	6	20.3	4.66		1.4	40.8
Polyarthra	42	29.8			8	13	1.87		1.8	40.8
Triarthra	17	8.5			10	10	1.37		1.6	42
Daphnia		1.6	4	4	12	8.9	.70		2	41.6
Ostracod				.8	15	8.3	.50			
Diaptomus	3.2	4.8	8	1.6						
Cyclops	21.6	26.4	11.2	1.6						
Nauplii	36	24	6.4	4.8	20	7.3	.62		2.4	42
Corethra			.8		24	6.6	.09		2.2	44
Melosira	59	115	217	85						
Fragillaria	311	477	159	29						
Asterionella										
Anabena	119	85		17						
Clathrocycetis	247	421	571	166						
Oscillatoria	328	324	294	123						
Lyngbya		960	793	55						

TABLE 68.  
LAKE: TURKEY (Big) (LaGrange and Steuben)  
Date: 8/18/30

[illegible]

TABLE 69.  
LAKE: NORTH TWIN  
Date: 9/2/30

[illegible]

TABLE 70.  
LAKE: SOUTH TWIN  
Date: 9/2/30

[illegible]

TABLE 71.  
LAKE: WALLEN LAKE  
Date: 8/24/30

[illegible]